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by

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In this work, we established experimentally the formation of fragmentation phenomena when sheet explosive charges act on metal plates. Ignition of the explosive was done in such a manner that the metal plate was loaded by a wave moving at the detonation velocity. The velocities of natural and artificial fragments were measured. The explosive used was a sheet alloy of trotyl plus hexogene 50/50, used to make sheet charges 80 × 150 mm. The variation in explosive charge thickness from experiment to experiment did not exceed ±0.1 mm. The test materials used were type ST3 steel, an aluminum alloy (AMG) and copper (M1). All materials were taken as delivered and given no heat treatment. In the experiments, a metal plate 150 × 200 mm, between 4 and 20 mm thick was used as a specimen. The artificial fragments were thin (0.1 mm) plates made of the same material. The measurement of velocities of artificial and natural fragments was performed by a photochronograph in transmitted light. The assembly was placed between the explosive light source and an SFR chamber.

The results of the measurement are presented in the Table, which shows the thickness of the explosive, metal plate; fragments formed, as well as the velocity of artificial and natural fragments, and the critical bursting stress required for the formation of fragments in the metals. The last column of the table shows the mean square errors of mean velocities of bursting stress. The value of critical bursting stresses was calculated using the following formula [1]:

$$\sigma_{кр} = \rho_м c_м \Delta U,$$

where ρ_m is the initial density of the metal; c_m is the initial velocity of sound. The following values for c_m were used, km/sec; for AMG -- 5.20; for Cu -- 3.95; for type 3 steel -- 4.63.

The difference in velocities ΔU can be evaluated as follows, considering that the shock wave enters the free surface of the metal plate at angle α:

$$\Delta U = \frac{W_н - W_е}{2\cos\alpha},$$

where W_H is the velocity of the artificial fragments; W_e is the velocity of the natural fragments; [1] $= c_m/D_{BB}$ (D_{BB} is the detonation velocity of the explosive).

The values of critical bursting stresses for steel, aluminum and copper produced in our work using the traveling supersonic load, are rather similar to the data of other works [2] and confirm the fact that the critical bursting stress for the formation of a fragment is not a constant quantity.

Using the data presented in the Table, we can estimate the nature of attenuation of shock wave amplitude (and mass velocity) as a function of the distance traveled by the shock wave. The figure shows the experimental results for copper M1, steel St.3 and aluminum alloy AMG in the dimensionless coordinates U_m/c_m:

$$\eta = \left(\frac{\rho_{BB} \cdot \Delta_{BB} \cdot D_{BB}}{\rho_M \cdot x_M \cdot c_M}\right)^{1/2}.$$

Here the values with the subscript BB relate to the explosive, with the subscript M to the metal; ρ is the density, and x is the path traveled by the shock wave in the metal, which is related to the thickness of the metal plate -- Δ_m -- as follows: $x = \Delta_m/\cos\alpha$.

The same figure shows the results for aluminum alloy AMTsAM sheets when sheets of plastic explosive with the parameters $\rho_{BB} = 1.5$ g/cm^3 and $D_{BB} = 7.5$ km/sec [3] were exploded on their surface.

We can see from the figure that the experimental points lie about a straight line.

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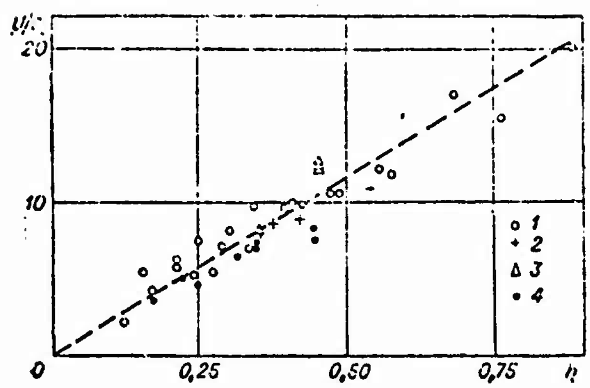
[1] Missing in original supplied for translation -- Tr.

Table

a Материал	b Толщина, мм: d листа ВВ	e металлической пластины, $\delta_м$	f отлома	c Скорость, м/сек: $W_н$	W_e	ΔW^*	$P_{кр}$, кг/мм²	$\bar{P}_{кр}$, кг/мм²	$\pm\sigma$, %
g Сталь 3	3	5	2,00	558	379	179	405	245	15
			2,12	539	401	128	28[illegible]		
		10	2,31	352	291	61	138		
		20	2,51	279	223	56	127		
	5	5	3,35	630	496	134	303		
			3,30	581	432	149	337		
		10	—	496	441	55	124		
		20	—	389	283	106	240		
h АМГ	3	8	2,20 (1,15)*	697	546	151	144	112	19
		10	—	676	600	76	72		
	5	8	2,68	856	732	124	118		
i Медь М1	3	5	—	559	412	147	290	378	9
			0,90	848	659	189	372		
	5	5	—	839	606	233	459		
			—	864	666	198	390		

* Second fragment

KEY: a, Material; b, Thickness, mm; c, Velocity, m/sec; d, Explosive sheet; e, Metal plate; f, Fragment; g, Type 3 steel; h, AMG; i, M1 copper



Attenuation of shock wave. 1, Aluminum alloy AMTsAM [3]; 2, St.3; 3, M1 copper; 4, AMG aluminum alloy

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13. ABSTRACT

Fragmentation phenomena as a result of the action of sheet explosive charges on metal plates is studied. A table is provided which shows the thickness of explosive used, type of plates. fragments formed and fragment velocity. Critical bursting stresses for steel, aluminum and copper are examined, and shock wave attenuation for various metals is shown graphically.

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